Fecal Coliform TMDL Development for One Segment in the Blackwater River Watershed, Florida

Blackwater River—Downstream Segment

Final

USEPA Region 4
61 Forsyth Street
Atlanta, GA 30303

February 2001

TOTAL MAXIMUM DAILY LOAD (TMDL) SUMMARY

NOTE: THIS FECAL COLIFORM TMDL REQUIRES *NO LOAD REDUCTIONS* OVER CURRENT CONDITIONS TO MEET WATER QUALITY STANDARDS

(THE LOAD ALLOCATION (LA) IS EQUAL TO THE TOTAL EXISTING NONPOINT SOURCE LOAD IN THE WATERSHED)

By definition: TMDL = WLAs + LAs + MOS

In terms of **concentration**:

Wasteload Allocation (WLA) = 0 fecal coliforms /100 ml
Load Allocation (LA) [+ Future Activities (Fut)] = 190 fecal coliforms /100 ml
Margin of Safety - explicit (MOS) = 10 fecal coliforms /100 ml

TMDL = WLA + LA + MOS + Fut = **200 fecal coliforms /100 ml**

In terms of **load**:

Blackwater River -- Map ID 4
Wasteload Allocation (WLA) = 2.63E+11 fecal coliforms /day
Load Allocation (LA) = 5.08E+17 fecal coliforms/30 days
Margin of Safety (MOS) = 2.67E+16 fecal coliforms/30 days
Reserve for Future Growth/Activities = 1.78E+13 fecal coliforms/30 days
TMDL = WLA + LA + MOS = **5.35E+17 fecal coliforms/30 days**

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1. INTRODUCTION

Levels of coliform bacteria can become elevated in waterbodies as a result of both point and nonpoint sources of pollution. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting designated uses even after technology-based controls are in place. The TMDL process establishes the allowable loadings of pollutants or other quantifiable parameters for a waterbody based on the relationship between pollutant sources and in-stream water quality conditions. By following the TMDL process, states can establish water quality-based controls to reduce pollution from both point and nonpoint sources and to restore and maintain the quality of their water resources (USEPA, 1991).

The Blackwater River watershed lies within the panhandle of northwest Florida, and its headwaters are in southern Alabama. The watershed is located almost entirely within Santa Rosa and Okaloosa counties in Florida with small portions in Escambia and Covington counties in Alabama (Figure 1-1). It is one of four major drainages of the Pensacola Bay system and flows into the Gulf of Mexico. The watershed is approximately 853 square miles (mi^2), with approximately 84 percent of that area (719 mi^2) in the state of Florida. The Blackwater River is designated for recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife (Class III).

Seven segments of the Blackwater River and its tributaries have been listed as coliform-impaired waterbodies and included in Florida's 1998 303(d) list, as adopted by the Florida Department of Environmental Protection (FDEP). The coliform impairment has resulted in nonattainment of designated uses, including recreation. The listed segments include the East Fork, West Fork, Manning Creek, Big Juniper Creek, Big Coldwater Creek, and two segments on the Blackwater River. TMDLs have previously been developed for all of these reaches except for the downstream segment of the Blackwater River. The objective of this study is to develop a TMDL for the 303(d)-listed downstream segment of the Blackwater River in the Blackwater River watershed.

Section 2 characterizes the study area, describes the designated uses associated with the resource, and identifies physical and land use characteristics. Section 3 inventories and evaluates relevant water quality data for the Blackwater River watershed. Section 4 identifies and characterizes the sources of fecal coliform with the Blackwater River watershed. Section 5 presents the modeling and analysis methodologies used to link source loading and water quality response. Section 6 presents the elements of the TMDL for the listed segment in the Blackwater River watershed.

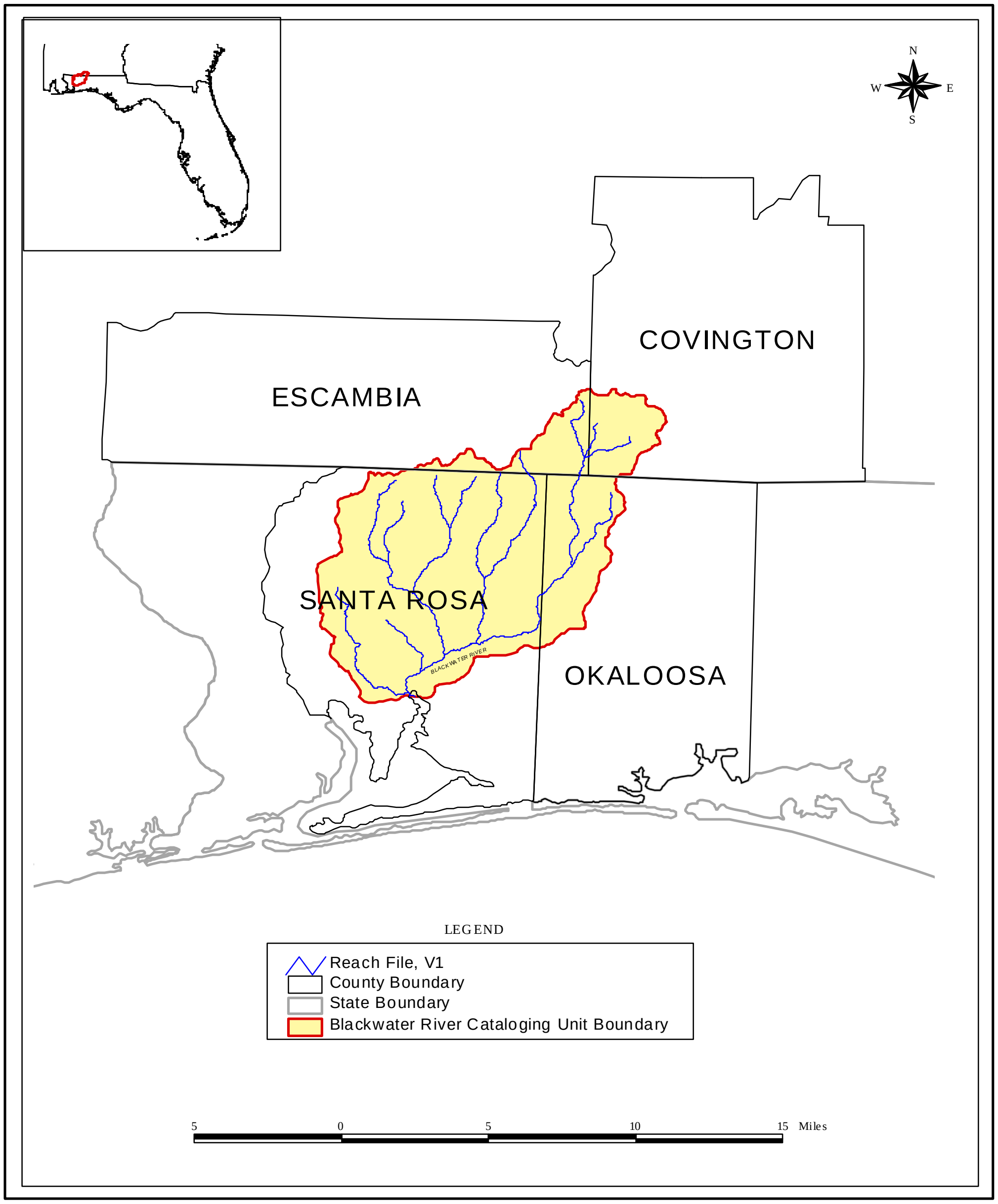

Figure 1-1. Location of the Blackwater River watershed

2. PHYSICAL CHARACTERISTICS

The purpose of this section is to characterize the Blackwater River watershed by identifying existing land uses, soils, topography, ecology, and land and resource management activities and by describing the water quality standards associated with this resource.

2.1 STUDY AREA

The listed segment is contained within the Blackwater River watershed, a drainage basin of approximately 853 mi^2, with approximately 719 mi^2 in Florida (Figure 2-1). The river originates in the Conecuh National Forest in southern Alabama. From the Florida-Alabama state line, it travels approximately 58 miles, with a gradient of 3.4 feet per mile, to Blackwater Bay and the Gulf of Mexico.

The Blackwater basin's sandy-bottom rivers are stained reddish-brown by tannic acids from swamp and forest drainage, which may account for its name. In general, the river is swift and shallow and is characterized by frequent sand bars (Hand, Col, and Lord, 1996). Groundwater from the Sand and Gravel Aquifer contributes a considerable amount of flow. The river system receives small contributions from surface flow; the primary source of flow is groundwater discharge (FDEP, 1998).

The major land uses within the basin are silviculture, agriculture, and preservation. The majority of the watershed is within the Blackwater State Forest and is managed by the Florida Department of Agriculture and Consumer Affairs, Division of Forestry. Numerous public and private recreation areas and facilities are directly or indirectly associated with the Blackwater River. The river, which flows through Blackwater State Forest and Blackwater State Park, is a favorite of canoeists and naturalists. Tourism continues to be a strong component of the area's economy, with fishing, hunting, hiking, and canoeing having long been mainstays of the region's economy (NWFWMD, 1996).

2.1.1 303(d)-Listed Segments

This TMDL study addresses the downstream segment of the Blackwater River identified on Florida's 1998 303(d) list as impaired by coliform bacteria (Figure 2-2). This subsection summarizes FDEP's description for the coliform-impaired segment (FDEP, 1998).

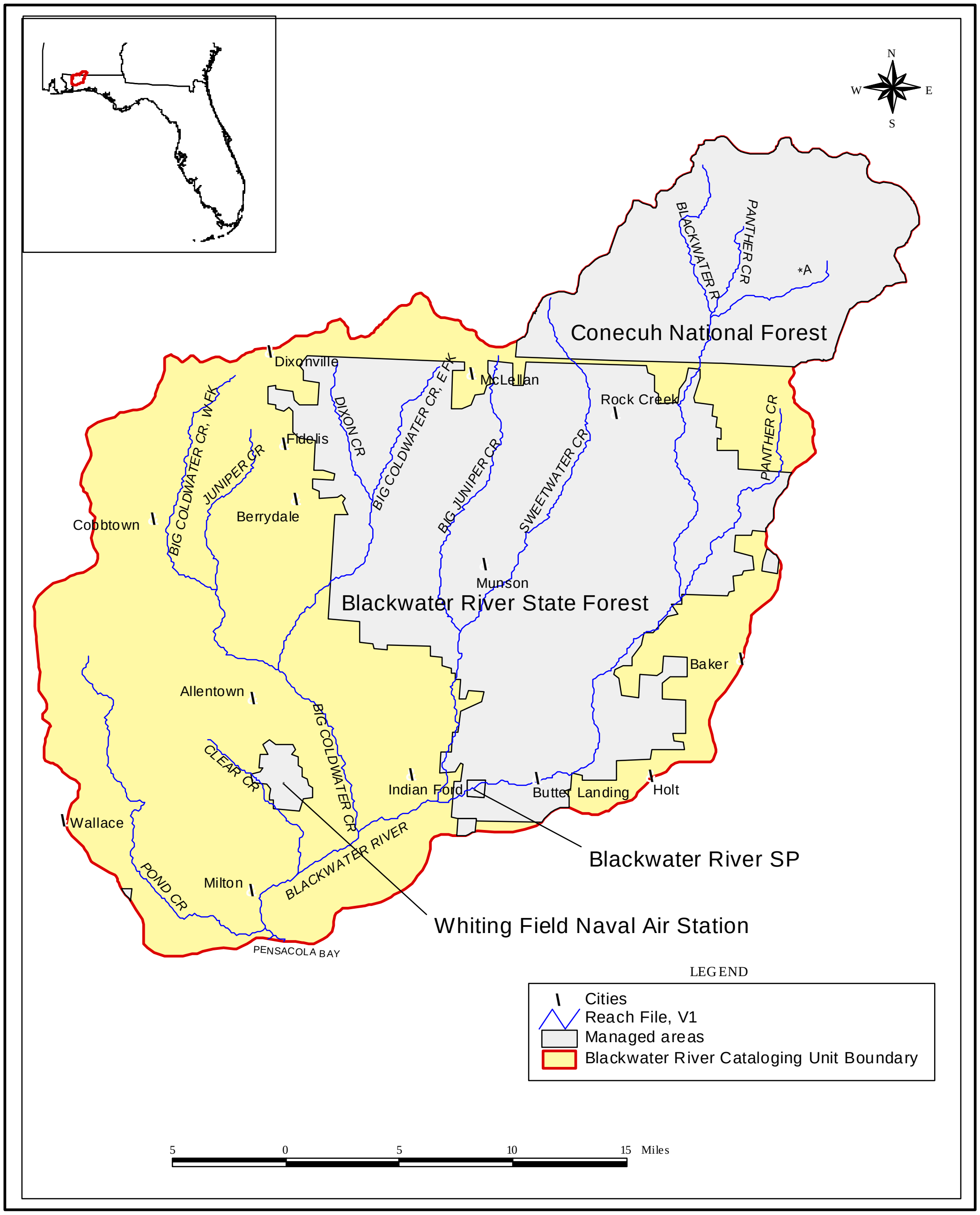

Figure 2-1. Blackwater River watershed

Blackwater River. Originating north of Bradley, Alabama, the Blackwater River flows approximately 58 miles before entering Blackwater Bay in northwestern Florida. Although the river system has small contributions from surface runoff, the primary source of flow is groundwater discharged from the Sand and Gravel Aquifer (FDEP, 1998).

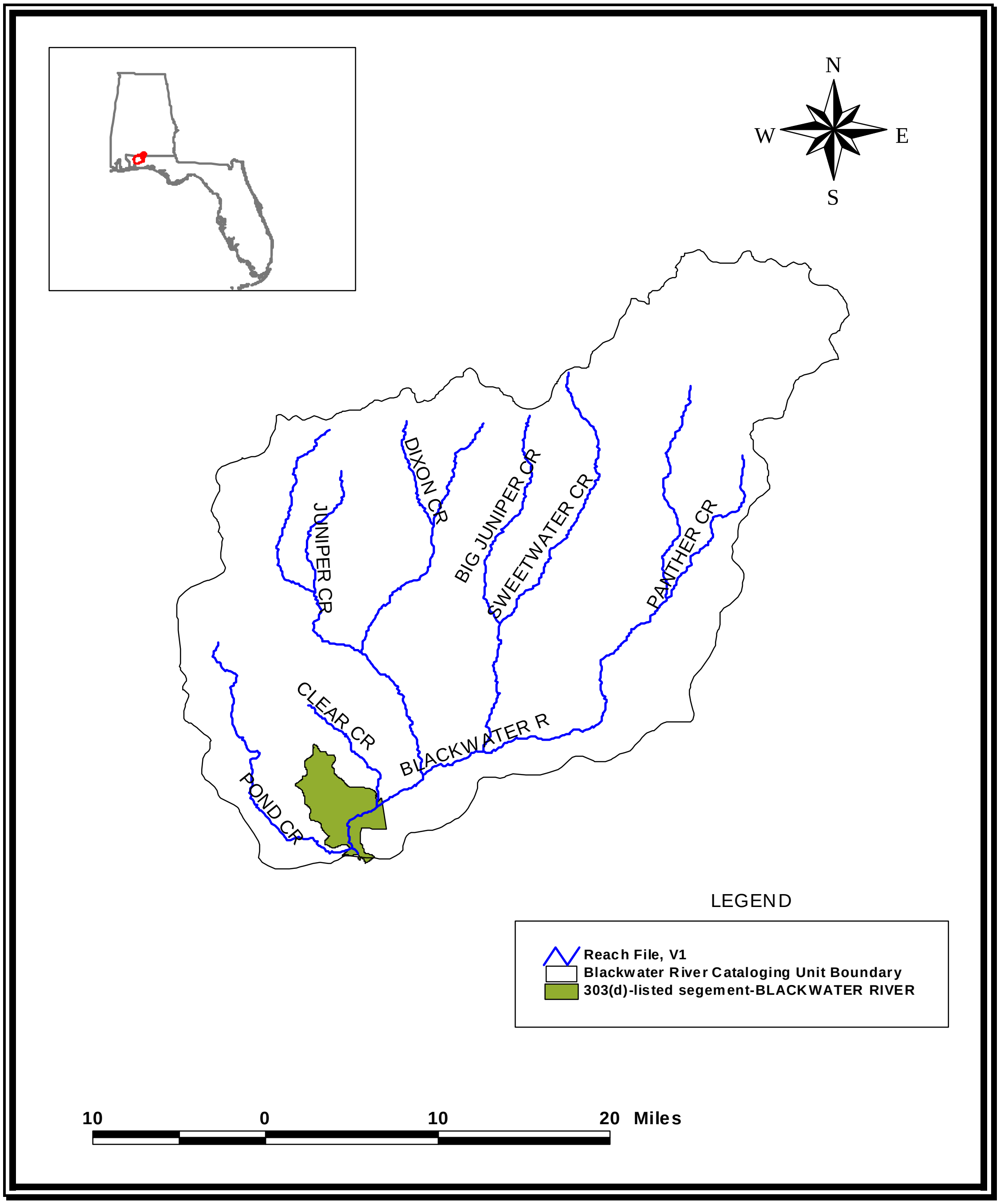

Figure 2-2. 303(d)-listed segments within the Blackwater River watershed

2.1.2 Topography, Geology, and Soils

The lower half of the Blackwater's main stem and most of Pond Creek drain the coastal plain. Sand is the principal substrate type throughout the upper watershed. In the coastal plain, sand bottoms grade gradually into the sand/mud and mud bottom of the estuary (Bass and Hitt, 1977). The streambed itself is known as a shifting sand system.

Elevations in the Blackwater River watershed range from 3 feet to 374 feet. The watershed's mean elevation is 190 feet.

2.1.3 Climate

Northwest Florida has a mild, subtropical climate. Average annual temperatures tend to be in the upper 60s (degrees Fahrenheit), with mean summer temperatures reaching the low 80s and mean winter temperatures dropping to the low 50s (NWFWMD, 1998a). Northwest Florida Water Management District (NWFWMD) maintained monthly temperature summaries and means for Pensacola and Crestview for the 1961 through 1990 period of record (Table 2-1).

Average precipitation is 62 inches, with March, July, August, and September being the wettest months and October and November being the driest. Peak rainfall is typically measured in the summer, specifically July (NWFWMD, 1998b). NWFWMD has summarized rainfall data accumulated over 30 years (1961-1990) for its Milton, Pensacola, and Crestview weather stations (Table 2-2).

2.1.4 Land Use

Timber production and agriculture are important economic land use activities within the Blackwater River watershed. Most of the watershed is within Florida's Blackwater River State Forest, with the headwaters in the Conecuh National Forest in Alabama. The land surrounding the river is, therefore, relatively protected from development.

FDEP provided land use coverages from 1995 for the Blackwater River watershed. The dominant land uses in the entire Blackwater River watershed are forest (approximately 70 percent), cropland/pasture (approximately 15 percent), and wetlands (approximately 11 percent). The 76 specific land use categories provided by FDEP were grouped into 8 broader categories for the TMDL analysis. Table A-1 in Appendix A contains a complete list of the Florida land use categories with the associated TMDL categories.

Table 2-1. Thirty-year monthly temperature summaries for the Blackwater River watershed

	Pensacola					**Crestview**				
	Monthly Avg. (FE)		**Daily Extreme (FE)**		**Mean (FE)**	**Monthly Avg. (FE)**		**Daily Extreme (FE)**		**Mean (FE)**
Month	**Max**	**Min**	**High**	**Low**		**Max**	**Min**	**High**	**Low**	
January	59.7	41.4	80	5	50.8	58.9	34.8	81	8	47.1
February	63.1	44.3	82	19	54.0	64.3	40.1	83	20	52.4
March	69.4	51.4	85	22	60.6	72.0	747.0	87	18	59.7
April	76.5	58.1	96	33	67.5	79.4	52.1	91	33	66.0
May	83.2	65.7	96	48	74.7	84.7	59.9	97	40	72.5
June	88.7	71.9	101	56	80.5	90.7	67.5	101	53	79.3
July	89.9	74.2	106	61	82.3	92.0	71.1	105	63	81.8
August	89.2	73.8	104	63	81.7	92.1	70.3	101	59	81.4
September	86.4	70.3	98	43	78.6	88.3	66.2	98	42	77.5
October	79.2	59.6	92	34	69.7	79.7	53.2	92	29	66.7
November	70.1	51.0	85	25	60.8	71.3	45.4	87	22	58.6
December	62.9	44.4	81	11	53.9	63.0	38.7	82	9	51.1
Annual Mean	-	-	-	-	67.9	-	-	-	-	66.2

Source: NWFWMD, 1998a.

Table 2-3 summarizes the land use distribution in the watershed of each 303(d)-listed segment, using the TMDL categories.

2.1.5 Hydrology and Channel Morphology

The Blackwater River watershed receives small contributions of flow from surface runoff and relatively large contributions of flow from the Sand and Gravel Aquifer (FDEP, 1998). Data in Table 2-4 characterize the channel geometry and flow for the 303(d)-listed segments within the Blackwater River watershed. Data for the Blackwater River come from Reach File, Version 1 (RF1).

Table 2-2. Thirty-year rainfall normals in northwest Florida

Month	Rainfall (inches)		
	Milton	Pensacola	Crestview
January	5.42	4.65	5.86
February	5.63	5.35	5.24
March	6.63	5.66	7.35
April	4.08	3.4	4.44
May	4.67	4.19	5.35
June	7.55	6.39	8.13
July	7.68	7.42	6.44
August	7.10	7.32	6.48
September	5.55	5.42	4.58
October	3.64	4.13	3.24
November	4.45	3.54	4.03
December	5.11	4.29	4.28
TOTAL	67.51	61.76	65.42

Source: NWFWMD, 1998b.

Table 2-3. Land uses in the watersheds of the 303(d)-listed Blackwater River (downstream segment) in the Blackwater River watershed

Land Use	Blackwater River—Downstream Segment (acres)
Cropland[a]	**22,187.56**
Forest/Vegetated	**124,241.10**
Open Land	**434.58**
Other	**860.09**
Pasture[a]	**10,463.96**
Residential	**11,253.98**
Urban	**4,506.36**
Wetlands	**17,493.35**
TOTAL	**191,440.98**

[a]Florida land use classification is "Cropland and Pasture." To separate into "Cropland" and "Pasture," the ratio of cropland and pasture from the 1997 Census of Agriculture for the appropriate counties was applied to the Florida classification.

Table 2-4. Channel geometry and flow information for the 303(d)-listed Blackwater River (downstream segment) in the Blackwater River watershed

Listed segment	Length (mile)	Mean flow (ft^3/s)	7Q10 (ft^3/s)	Slope	Mean depth (ft)	Mean width (ft)
Blackwater River (downstream segment)	3.7	1250.48	312.08	.00015	2.62	169.80

2.2 Resource Management Issues

The Blackwater River watershed area is contained within four counties in two states and traverses a national forest, a state forest, and a state park, making it subject to management by several federal, state, and local agencies.

2.2.1 Chapter 62, Florida Administrative Code

Water Quality Standards

Florida's surface water quality standards, as established in Chapter 62-302 of the Florida Administrative Code, vary according to a waterbody's surface water classification. The Blackwater River is a Class III freshwater waterbody designated to be used for recreation and the propagation and maintenance of a healthy, well-balanced population of fish and wildlife. Water quality classifications are arranged in order of the degree of protection required: Class I waters generally have the most stringent water quality criteria and Class V waters generally have the least stringent. Criteria applicable to a classification are designed to maintain the minimum conditions needed to ensure the suitability of water for the designated use of the waterbody.

The Florida standard for bacteriological quality for fecal coliform bacteria specifies the following:

> The number per 100 mL (Most Probable Number [MPN] or membrane filter [MF] counts) shall not exceed a monthly average of 200, nor exceed 400 in 10 percent of the samples, nor exceed 800 on any one day. Monthly averages shall be expressed as geometric means based on a minimum of 10 samples taken over a 30 day period (Chapter 62-302.530 F.A.C.).

Outstanding Florida Waters Designation

Chapter 62-302.700 of the Florida Administrative Code (F.A.C.) affords special protection to waterbodies designated by Florida as Outstanding Florida Waters (OFW) or Outstanding National Resource Waters (ONRW). Under this designation no degradation of water quality, other than that allowed in Rule 62-4.242(2) and (3), F.A.C., is to be permitted. The Blackwater River is afforded special protection under Chapter 62-302.700 because of its designation as a Special Water and an OFW.

2.2.2 State Resource Management Agencies

Florida Department of Environmental Protection

The FDEP is Florida's principal environmental and natural resources agency. It is responsible for regulating air, water, wastewater, storm water, and hazardous waste pollution through a permitting and certification process (FDEP, 1998). FDEP implements the OFW program, enforces water quality standards, and administers aquatic preserves. Its mission is to protect, conserve, and manage Florida's environment and natural resources. FDEP accomplishes its mission in a manner that

- Provides stewardship of Florida's ecosystems so that the state's unique quality of life may be preserved for present and future generations
- Protects the public health and safety
- Provides for the responsible and wise use of the state's mineral, cultural and living resources
- Provides efficient and equitable service to the public
- Provides consistent and impartial implementation of the law

FDEP's Northwest District office, located in Pensacola, facilitates management of the Blackwater River system.

Pensacola Bay Ecosystem Management Area. The Blackwater River watershed lies within the Pensacola Bay Ecosystem Management Area (EMA). This EMA is managed by a group of elected local officials acting as a coordinating council under the name Bay Area Resource Council (BARC). A Citizens Advisory Committee (CAC) and a Technical Advisory Committee have suggested that the BARC put together a team to evaluate sampling data and put it in a form so it can be displayed on an Internet site and made available to all who are interested. The CAC is also developing ideas on septic tank ordinances, impact fees for large developments, and storm water management.

Blackwater Heritage State Trail (Rails to Trails). This is a greenways project that will provide a corridor between the Blackwater Forest and the city of Milton. An abandoned railroad is being converted to a walking and bicycle trail.

Blackwater River State Park. The Blackwater River State Park is a 590-acre state park in Florida. With three hiking trails and 30 campsites, the park attracts canoeists, hikers, and outdoor enthusiasts. Hunting, livestock grazing, and timber removal are prohibited within the park.

Northwest Florida Water Management District

Since its establishment in 1972, the NWFWMD has been involved in efforts to understand and appropriately manage northwest Florida's water resources. Research and management efforts have included studies of sedimentation, fish populations, thermal anomalies, and submerged vegetation in the effort to manage lands to facilitate the conservation and restoration of their natural, aesthetic, hydrologic, and recreational values.

Florida Department of Agriculture and Consumer Services

The Florida Department of Agriculture and Consumer Services (DACS) is responsible for regulating the purchase and use of restricted pesticides. It also assists the federal Natural Resources Conservation Service (NRCS) with soil and water conservation.

Florida Game and Freshwater Fish Commission

The Florida Game and Freshwater Fish Commission (FGFWFC) has regulatory and management jurisdiction over game and nongame wildlife and freshwater aquatic life.

Alabama State Agencies

Alabama agencies responsible for management of the Blackwater River watershed include the Alabama Department of Environmental Management, the Department of Conservation and Natural Resources, and the Game and Fish Division of the Department of Conservation and Natural Resources.

2.2.3 Federal Resource Management Agencies

Federal laws relevant to the Blackwater River basin include the National Flood Insurance Act of 1968, Clean Water Act of 1977 (amended 1987), National Environmental Policy Act of 1969, and Endangered Species Act of 1973 as amended. Federal agencies responsible for implementing these laws include the U.S. Geological Survey (USGS), U.S. Fish and Wildlife Service (USFWS), Natural Resources Conservation Service (NRCS), National Oceanic and Atmospheric Administration (NOAA), U.S. Air Force, U.S. Army Corps of Engineers, and U.S. Environmental Protection Agency (EPA).

3. INVENTORY OF WATERSHED INFORMATION

This section presents an overview of the in-stream water quality monitoring data for the Blackwater River and discusses potential point and nonpoint sources of fecal coliform loading. The purpose is to inventory available data that are appropriate to use in developing a coliform TMDL. Water quality data related to coliform bacteria for the Blackwater River watershed were collected from EPA's STORET database.

3.1 EXISTING MONITORING AND FIELD ASSESSMENT DATA

3.1.1 Water Quality Data

A number of state and federal agencies have conducted water quality monitoring within the Blackwater River watershed since the 1960's. EPA, USFS, USGS, FDEP, and NWFWMD have all monitored for fecal coliform bacteria.

A comprehensive search for the Blackwater River watershed was conducted in EPA's STORET database, which includes data from USGS, EPA, FDEP, USFS, and NWFWMD databases. Sixty existing or past monitoring stations within the entire Blackwater River watershed have at least one observation of fecal coliform reported in STORET. Data used to evaluate general water quality conditions over the entire Blackwater River watershed were limited to data collected at stations with a minimum of five data points for fecal coliform between 1980 and 1998. Using this criterion, data from 8 of the 60 monitoring stations were evaluated to assess current water quality conditions in the watershed. Table 3-1 summarizes the water quality data collected at the 8 monitoring stations, including minimum, median, and maximum fecal coliform levels, as well as the percent of collected samples that violate water quality standards. Data were compared to the instantaneous criteria in the state water quality standards—no sample to exceed 800 cfu/100 mL at any time for fecal coliform. Two of the 8 stations are located within the watersheds of the listed segment. The available water quality monitoring stations are displayed in Figure 3-1. The actual data used to evaluate the water quality conditions in the Blackwater River watershed (downstream segment) are presented in tables Appendix B.

Table 3-1. Summary of in-stream fecal coliform data collected at monitoring stations (with at least 5 samples from 1980 to 1998) on the 303(d)-listed segment of the Blackwater River (downstream segment)

Station	Location	Period of Record	No. of Samples	Min	Median	Max	Violations of WQS[a]	Percent Violating[b]
Blackwater River (downstream segment)								
33030020	CLEAR CR SR 191 BRI NE MILTON	8/26/80-1/26/98	21	10	50	800	0	0
33030028	BLACKWATER RIVER BELOW GRAIN ELE	1/7/90-1/26/98	23	10	140	3420	2	8.7
33030019	POND CR HWY 90 BR W MILTON	9/17/80-1/26/98	73[c]	1	140	4300	7	9.6
33030011	BLACKWATER RI N HWY 90 BR	8/26/80-1/26/98	26	20	130	2200	1	3.8
33030013	BLACKWAT RI S MILTON STP OUTFALL	8/26/80-3/3/81	5	43	60	2400	1	20
33030017	BLACKWATER RI MO BIG COLDWATE CR	8/14/80-5/27/97	17	4	44	1060	1	5.9
33030026	BLACKWATER RIVER N OF HAROLD	7/1/97-11/25/97	22	10	40	720	0	0
33030042	PANTHER CR JHN RILEY BARNHILL RD OKA.CO.SECT.11	8/18/92-2/22/96	7	10	60	200	0	0

[a] Standard: Not to exceed 800 cfu/100 mL at any time

[b] Percent of samples that violate water quality standard of 800 cfu/100 mL at any time

[c] Some samples were excluded from statistical analysis because too many colonies were present to count. The value reported represents the filtration volume.

3.1.2 Flow Data

There are 10 USGS flow gaging stations within the Blackwater River watershed. Table 3-2 provides an inventory of the USGS gages within the watershed. Also listed in the table is the period of record of available continuous daily flow data. Figure 3-1 presents the USGS gage stations located in the Blackwater River watershed.

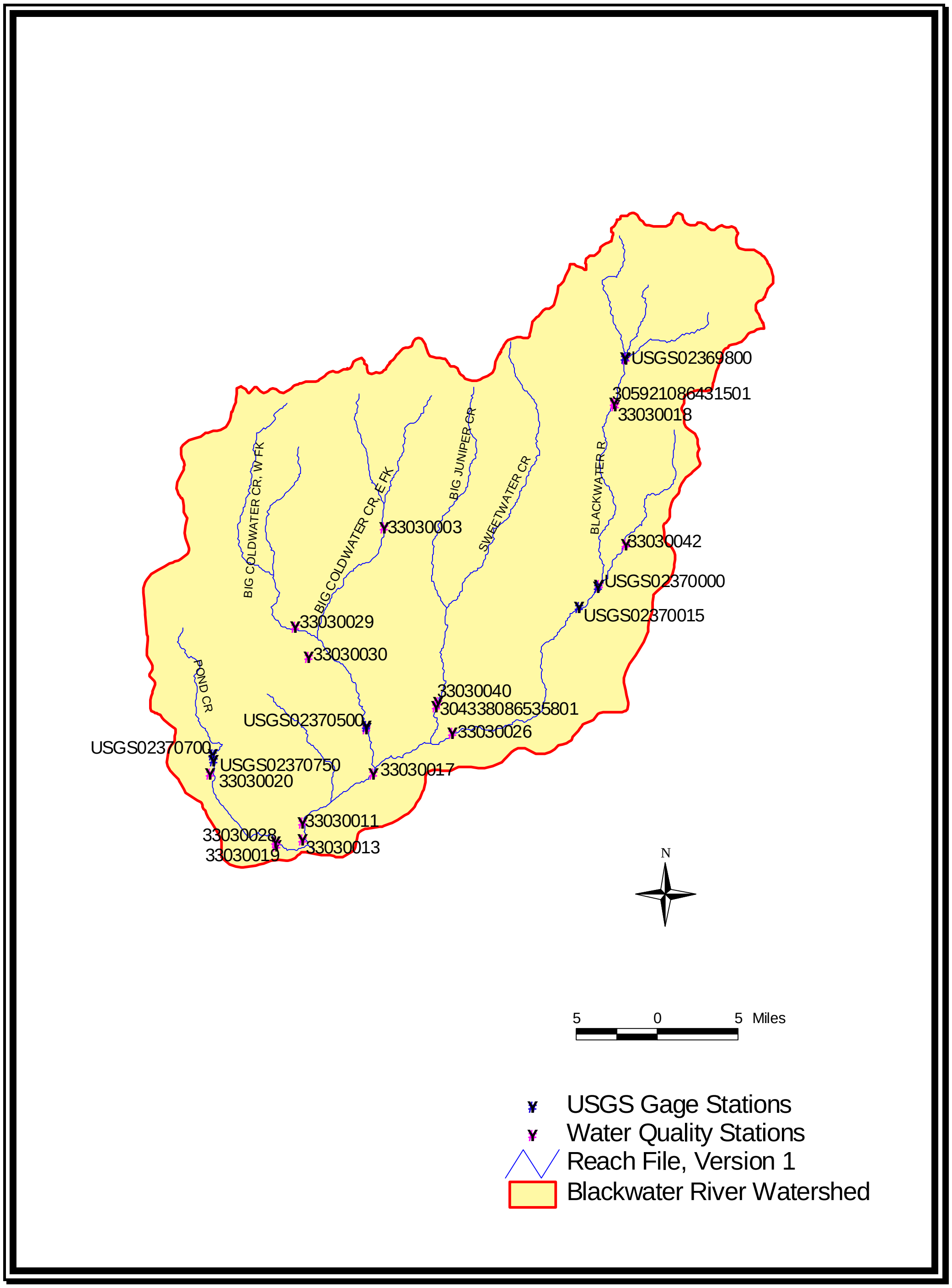

Figure 3-1. Water quality monitoring stations with at least 5 fecal coliform data points from 1980 to 1998 and USGS gage stations in the Blackwater River watershed

Table 3-2. USGS flow gages within the Blackwater River watershed

Station No.	Station Name	County	Period of Record[a]
02370000	Blackwater River near Baker, FL	Okaloosa	4/1/50-11/30/92; 10/1/96-9/30/97
02370015	Muddy Branch near Beaver Creek, FL	Okaloosa	n/a[b]
02370200	Big Juniper Creek near Munson, FL	Santa Rosa	1/1/58-12/31/66
02370250	Big Juniper Creek near Spring Hill, FL	Santa Rosa	n/a[a]
02370300	West Fork Big Coldwater River at Cobbtown, FL	Santa Rosa	1/1/58-12/31/61
02370500	Big Coldwater Creek near Milton, FL	Santa Rosa	12/1/38-6/11/79; 2/13/80-4/22/80; 7/15/80-3/3/92
02370550	Clear Creek near Milton, FL	Santa Rosa	n/a[b]
02370700	Pond Creek near Milton, FL	Santa Rosa	1/1/58-11/30/78; 1/16/79-7/11/79
02370750	Hurricane Branch near Milton, FL	Santa Rosa	n/a[b]
02369800	Blackwater River near Bradley, AL	Escambia	10/1/67-9/30/97

[a] Period of record for daily flow data. Does not include peak flow data.
[b] Only peak flow data are available for this station.

4. SOURCE ASSESSMENT

Potential sources of coliform bacteria are numerous and often occur in combination. Potential point sources include poorly treated municipal sewage, urban storm water runoff, sanitary sewer overflows, combined sewer overflows (CSOs), and untreated domestic sewage. Potential nonpoint sources include manure disposal and runoff of animal waste from feedlots, disposal and handling of poultry litter, failing or ill-sited septic systems, runoff from pasturelands, application of manure or municipal sludge to cropland and other agricultural areas, and loadings from various wildlife species.

4.1 ASSESSMENT OF POINT SOURCES

A significant potential source of human fecal coliform from point sources is raw sewage. Raw sewage typically has a total coliform count of 10^7 to 10^9 MPN/100 mL and 10^6 to 10^7 fecal coliform counts/100 mL (Novotny and Olem, 1994), along with significant concentrations of fecal coliform bacteria, viruses, protozoans, and other parasites. Typical treatment in a municipal plant reduces the total coliform count in effluent by about three orders of magnitude, to the range of 10^4 to 10^6 MPN/100 mL. Raw sewage, although usually not discharged intentionally, can reach waterbodies through leaks in sanitary sewer systems, overflows from surcharged sanitary sewers (non-combined sewers), illicit connections of sanitary sewers to storm sewer collection systems, or unidentified broken sewer lines.

EPA's permit compliance system (PCS) files were queried to identify and characterize any point sources discharging fecal coliform bacteria within the watersheds of the listed segment of the Blackwater River (downstream segment). One major point source was identified. The Milton STP has a permit flow limit of 1.8 mgd and discharges into the Blackwater River. The maximum permitted fecal coliform discharge concentration of 200 counts/100 mL was assumed for the Milton STP.

4.2 ASSESSMENT OF NONPOINT SOURCES

Nonpoint sources of fecal coliform bacteria are typically separated into urban and rural components. Urban settings are typically characterized by larger areas of paved impervious surfaces. Important sources of coliform loads in urban areas are storm runoff from impervious areas, failing septic tanks, and leaking sanitary sewer systems. In rural settings, the amount of impervious area is usually much lower, resulting in greater infiltration of precipitation and less runoff. Sources of fecal coliform in rural areas may include runoff from fields receiving land application of animal wastes, runoff from concentrated animal operations, contributions from wildlife, cattle in the stream, and failing septic tanks (IFAS, 1998).

The Blackwater watershed was evaluated to identify and quantify sources of bacteria within the watersheds of the listed segment. The identified nonpoint sources of fecal coliform bacteria within the watersheds of the listed segment include:

- Runoff from pasturelands with grazing livestock
- Runoff from cropland
- Failing septic systems
- Wildlife contributions
- Cattle in streams
- Runoff from residential and urban areas

Potential sources of nonpoint pollution in the Blackwater watershed include failing septic systems, runoff from pasture lands, wildlife and cattle secretion in stream reaches. Septic systems are common in unincorporated portions of the watershed and may be direct or indirect sources of bacterial pollution via ground and surface waters. Although specific information regarding agricultural management practices and activities are not readily available, agricultural census data can be used to evaluate the loading of fecal coliform from pasture lands. Wildlife data are available from Florida Fish and Wildlife Conservation Comission.

For the purpose of source assessment and ultimately modeling, the state of Florida’s subwatershed coverage was used. This coverage provided a basis for subdividing the Blackwater River into smaller hydrologic units. In some situations, the Florida subwatersheds were further subdivided based on the location of monitoring stations and the distribution of land use. The lower portion of the Blackwater River watershed was divided into 38 subwatersheds, which include the 303(d)-listed segment of the downstream segment of the Blackwater River. By dividing the watershed into subwatersheds, pollutant sources and loading were more accurately evaluated. The upper portion of the Blackwater River watershed was previously delineated for modeling the Big Coldwater Creek, Big Juniper Creek, and Upper Blackwater River watersheds (see Fecal Coliform TMDL Development for seven Segments in the Blackwater River Watershed, Florida, November 1999). The output from these earlier models were used as input to the lower portion of the watershed in order to represent flows and fecal coliform loads draining into the 303(d)-listed segment of the Blackwater

River. Figure 4-1 presents the watersheds of Big Coldwater Creek, Big Juniper Creek, and the Upper Blackwater River, as well as the 38 subwatersheds in the lower portion of the Blackwater River watershed. The following sections provide information on the characterization and quantification of bacteria sources within the listed watershed.

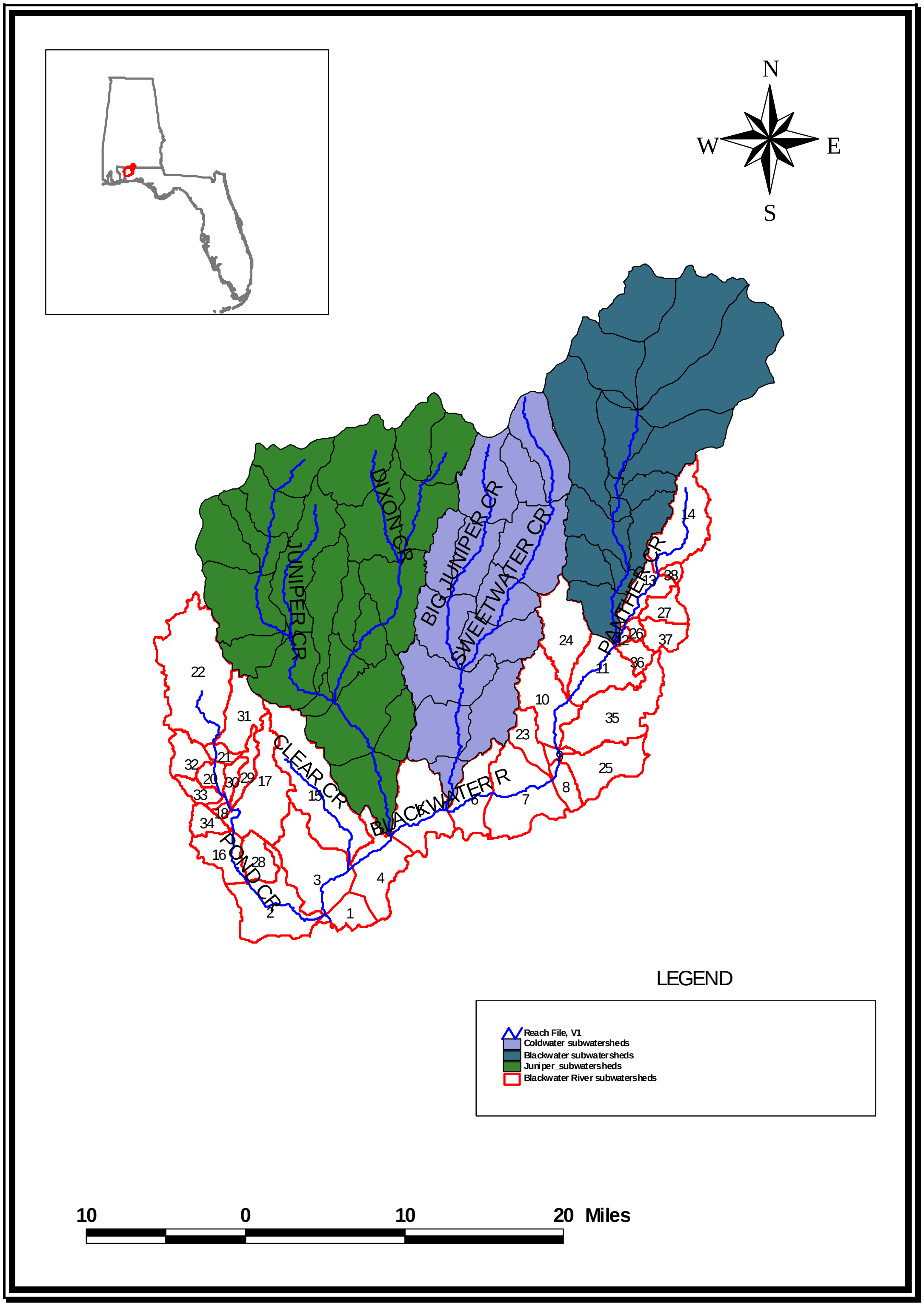

Figure 4-1. Subwatersheds within the Blackwater River watershed (downstream segment)

4.2.1 Grazing Livestock

Grazing cattle and other agricultural animals deposit manure and, therefore, fecal coliform on the land surface, where it is available for washoff and delivery to receiving waterbodies. Grazing animals in the watersheds of the Blackwater River contribute fecal coliform to pasture land. Data from the 1997 Census of Agriculture provided numbers of livestock in each county covering portions of the watersheds, as well as total pastureland within each county. The livestock counts and pasture areas were used to determine livestock densities (e.g., number of cows per acres of pastureland) for each county, assuming livestock are evenly distributed over pasture area in the county. The area of pastureland in each subwatershed and within each county was determined using GIS data layers.

Estimates for hogs and chickens are included in the following tables although originally it was assumed that there are not many hog or chicken farms in the watersheds based on personal communication with NRCS. Therefore, hogs and chickens are not considered to be significant sources of fecal coliform bacteria to the waterbodies. Also the counties of Escambia, Covington, Jackson, and Walton did not have Ag Census data for chickens, so the watersheds in those respective counties do not have livestock counts for chickens.

The subwatershed livestock counts are presented in the following section for the Blackwater River watershed.

Table 4-2 presents the livestock counts for each subwatershed within the Blackwater River watershed (downstream segment).

Table 4-1. Livestock counts for subwatersheds within the Blackwater River watershed (downstream segment)

ID	Subwatershed	Pasture (acres)	Cattle/Calves	Beef Cows[a]	Milk Cows[a]	Sheep/Lambs	Hogs	Chickens
1	1	52.25	120	62	1	2	4	0
2	2	114.09	261	134	2	5	8	0
3	3	65.90	151	78	1	3	5	0
4	4	304.53	697	359	7	13	21	0
5	5	141.65	324	167	3	6	10	0
6	6	74.60	171	88	2	3	5	0
7	7	140.37	321	165	3	6	10	0
8	8	147.44	407	142	0	0	35	26
9	9	3.40	8	4	0	0	0	0

ID	Subwatershed	Pasture (acres)	Cattle/Calves	Beef Cows[a]	Milk Cows[a]	Sheep/Lambs	Hogs	Chickens
10	10	71.56	164	84	2	3	5	0
11	11	1085.10	2999	1042	4	0	255	191
12	12	0.00	0	0	0	0	0	0
13	13	86.16	238	83	0	0	20	15
14	14	603.43	1668	580	2	0	142	106
15	15	874.71	2001	1031	19	36	31	0
16	16	79.66	182	94	2	3	6	0
17	17	568.77	1301	670	12	23	39	0
18	18	3.87	9	5	0	0	0	0
19	19	17.82	41	21	0	1	1	0
20	20	27.50	63	32	1	1	2	0
21	21	0.00	0	0	0	0	0	0
22	22	1440.56	3295	1698	31	59	100	0
23	23	33.15	76	39	1	1	2	0
24	24	561.73	1285	662	12	23	39	0
25	25	551.09	1523	529	2	0	129	97
26	26	6.96	19	7	0	0	2	1
27	27	205.06	567	197	1	0	48	36
28	28	96.81	221	114	2	4	7	0
29	29	72.05	165	85	2	3	5	0
30	30	10.55	24	12	0	0	1	0
31	31	231.66	530	273	5	10	16	0
32	32	173.67	397	205	4	7	12	0
33	33	49.49	113	58	1	2	3	0
34	34	34.61	79	0	0	1	2	0
35	35	1691.27	4674	1625	6	0	397	298
36	36	145.47	402	140	0	0	34	26
37	37	696.54	1925	669	2	0	164	123
38	38	0.46	1	0	0	0	0	0
TOTAL		10463.96	26421	11156	131	215	1590	918

[a] Numbers for beef cows and milk cows were not available in the Census of Agriculture for Santa Rosa County, FL, for 1997 or 1992. Counts used to calculate livestock in subwatershed portions within Santa Rosa County represent 1987 data.

4.2.2 Failing Septic Systems

Onsite septic systems have the potential to deliver bacteria loads to surface waters due to system failure and malfunction. NSFC (1993) provided estimates of failing septic systems for each county within the Blackwater River watershed. The number of failing systems in each subwatershed was then estimated based on county area and subwatershed area within each county. Without knowing the spatial distribution of septic systems, functioning or failing, it was assumed that failing systems are distributed evenly throughout their corresponding counties. A density of failing septic systems (number per acre) was determined for each county by dividing the number of failing systems by the total county area. The densities were then applied to the area of the subwatershed in each respective county to determine the number of failing systems in the area where the subwatershed and county intersect. These county/subwatershed estimates were summed to determine the total number of failing septic systems in the subwatersheds. The septic failure rates for Santa Rosa and Okaloosa counties are 0.01 percent and 0.02 percent, respectively.

The following section presents the estimates of the number of failing septic systems in the subwatersheds in the Blackwater River (downstream segment) listed watershed.

Table 4-3 presents the number of failing septic systems for each subwatershed within the Blackwater River watershed (downstream segment).

Table 4-2. Inventory of failing septic systems in the subwatersheds of the Blackwater River watershed (downstream segment)

ID	Subwatershed	Subwatershed Area (acres)	Failing Septic Systems
1	1	2,919	1
2	2	9,491	4
3	3	10,951	5
4	4	7,821	4
5	5	9,249	4
6	6	6,209	3
7	7	11,116	5
8	8	2,213	1
9	9	720	0
10	10	7,934	4
11	11	6,862	2
12	12	433	0

ID	Subwatershed	Subwatershed Area (acres)	Failing Septic Systems
13	13	3,645	1
14	14	8,729	3
15	15	15,584	7
16	16	4,170	2
17	17	9,813	5
18	18	429	0
19	19	269	0
20	20	1,577	1
21	21	1,080	1
22	22	17,457	8
23	23	3,232	1
24	24	7,912	4
25	25	6,936	2
26	26	722	0
27	27	2,465	1
28	28	3,072	1
29	29	1,890	1
30	30	1,194	1
31	31	5,300	2
32	32	3,003	1
33	33	1,597	1
34	34	1,894	1
35	35	11,013	4
36	36	1,672	1
37	37	2,664	1
38	38	686	0
TOTAL		193,943	84

The fecal coliform loading rates from failing septic systems used in developing TMDLs for the Blackwater River watershed are presented in Table C-1 in Appendix C.

4.2.3 Wildlife

Wildlife is another potential source of fecal coliform loading to receiving waterbodies. For this TMDL, the deer population is assumed to represent the wildlife contribution. It is also assumed that deer habitat within the watershed includes Forest/Vegetated, Cropland, Wetlands, Open Land, and Pastureland uses. Estimates for distributions of deer were provided by the Florida Fish and Wildlife Conservation Commission (personal communication, August 27, 1999). Three different densities (deer per square mile) were available for the watershed, representing different management areas. Estimates are determined based on "track estimates" where the ground is cleared, and then animal tracks are counted to estimate populations within an area. The provided densities were applied to deer habitat areas within the watershed to estimate population counts by subwatershed. The highest density (5.8 deer/mi^2) was applied to the Forest/Vegetated, Cropland, and Wetlands areas, and the lowest density (2.9 deer/mi^2) was applied to Open Land and Pasture areas. The following sections present the inventories of deer in each subwatershed by land use considered deer habitat.

Table 4-3 presents the wildlife counts by land use for each subwatershed within the Blackwater River watershed (downstream segment).

Table 4-3. Wildlife counts for each subwatershed within the Blackwater River watershed (downstream segment)

ID	Subwatershed	Cropland	Forest/Veg.	Open Land	Pasture	Wetlands	Total
1	1	2	9	0	0	8	19
2	2	3	42	1	1	3	50
3	3	2	46	0	0	7	55
4	4	9	38	0	2	7	56
5	5	4	64	0	1	12	81
6	6	2	42	0	0	8	52
7	7	4	78	0	1	12	95
8	8	2	13	0	1	3	19
9	9	0	5	0	0	1	6
10	10	2	5	0	0	14	21
11	11	12	27	0	5	10	54
12	12	0	3	0	0	1	4
13	13	1	26	0	0	5	32
14	14	7	56	0	3	8	74
15	15	25	80	1	4	6	116
16	16	2	28	0	0	2	32
17	17	16	58	0	3	3	80
18	18	0	3	0	0	0	3
19	19	2	1	0	0	0	3
20	20	1	12	0	0	2	15
21	21	0	9	0	0	1	10
22	22	41	92	0	7	8	148
23	23	1	25	0	0	12	38

24	24	6	50	0	3	8	67
25	25	6	43	0	3	3	55
26	26	0	6	0	0	1	7
27	27	2	15	0	1	2	20
28	28	3	15	0	1	1	20
29	29	2	14	0	0	1	17
30	30	0	10	0	0	0	10
31	31	7	34	0	1	4	46
32	32	5	19	0	1	1	26
33	33	1	11	0	0	1	13
34	34	1	15	0	0	1	17
35	35	19	53	0	9	7	88
36	36	2	11	0	1	1	15
37	37	8	5	0	4	1	18
38	38	0	6	0	0	1	7
	TOTAL	200	1,069	2	52	166	1,489

4.2.4. Cattle in the Stream

When cattle are not denied access to stream reaches, they represent a major potential source of direct fecal coliform loading to the stream. To account for the potential influence of cattle loads deposited directly in stream reaches within the watersheds, fecal coliform loads from cattle in streams were calculated and characterized as a direct source of loading to the stream segments. To determine the number of cows in the stream at any time, it was assumed that 10 percent of the cows in the watershed have access to streams; that 7 percent of those cows are in or around the stream at any given time; and that 5 percent of those cows in the stream are actually depositing manure in the stream reach at any given time. The fecal coliform loading rates from cattle in the stream used in developing TMDLs for the Blackwater River watershed are presented in Table C-2 in Appendix C.

4.2.5 Critical Conditions

While selecting a numeric endpoint, TMDL developers must also select the environmental conditions that will be used for defining allowable loads. Many TMDLs are designed around the concept of a “critical condition.” The critical condition is the set of environmental conditions which, if controls are designed to protect, will ensure attainment of objectives for all other conditions.

Nonpoint source loading is typically precipitation-driven. In-stream impacts tend to occur during wet weather and storm events that cause surface runoff to carry pollutants to waterbodies. During dry periods, little or no land-based runoff occurs, and elevated in-stream bacteria levels may be due to point sources (Novotny and Olem, 1994). Because the majority of available water quality monitoring data for the Blackwater River watershed do not have corresponding flow measurements, it is difficult to evaluate critical flow conditions. Without corresponding flow values, it is difficult to determine whether elevated bacteria levels occur during base flow, indicating pollution from point sources and failing septic systems, or during high-flow events, indicating pollution from nonpoint sources.

In the Blackwater River watershed, USGS flow gage 02370000 and FDEP water quality station 33030001 are located at the same site. Plotting the continuous flow from 02370000 and plotting the single samples from 33030001 on their measurement dates suggests that flow and coliform concentrations follow the same relative pattern, with higher coliform levels corresponding to higher flow values. This is, however, a relatively crude comparison using the best available data.

5. LINKAGE OF SOURCES AND WATER QUALITY RESPONSE

5.1 SELECTED WATERSHEDS

Seven segments on the main stem of or tributaries to the Blackwater River are listed on Florida's 1998 303(d) list as impaired by fecal coliform. One of these segments is the Blackwater River (downstream segment) and it is considered for TMDL development in this study. This section presents the technical approach used for developing the source and response linkage for the Blackwater River (downstream segment) watershed.

5.2 TMDL ENDPOINT

Because the Blackwater River and its tributaries have associated numeric criteria in their water quality standards for fecal coliform, those applicable numeric criteria would represent the in-stream water quality target for TMDL development. The coliform TMDL developed for the impaired segment in the Blackwater River watershed will establish wasteload and load allocations that would allow for the attainment of the coliform bacteria water quality standard of a monthly average of 200 counts/100 mL, expressed as a geometric mean based on a minimum of 10 samples taken over a 30-day period. The model output provides continuous daily concentrations to compare to the water quality standards.

5.3 LINKAGE OF SOURCES AND TMDL ENDPOINT

Establishing the relationship between the in-stream water quality target and the source loadings is a critical component of TMDL development. It allows for the evaluation of management options that will achieve the desired source load reductions. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that indicate a waterbody's response to flow and loading conditions. The following sections provide discussion of the modeling tools and model setup and application.

5.3.1 Modeling Framework

USEPA's Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) system Version 2.0 (USEPA, 1998b) and the Nonpoint Source Model (NPSM) were used to predict the significance of coliform sources and levels in the Blackwater River watershed. BASINS is a multipurpose environmental analysis system for use in performing watershed and water quality-based studies. A geographic information system

(GIS) provides the integrating framework for BASINS and allows for the display and analysis of a wide variety of landscape information (e.g., land uses, monitoring stations, point source dischargers). The NPSM simulates nonpoint source runoff from selected watersheds, as well as the transport and flow of pollutants through stream reaches. It produces time series data, allowing for sufficient data to compare to the water quality target in the analysis. Another key reason for using BASINS and the NPSM as the modeling framework is their ability to integrate both point and nonpoint source simulation, as well as to assess instream water quality response.

5.3.2 Model Setup

Existing models of the Big Coldwater Creek , the Big Juniper Creek, and Upper Blackwater River waterhsheds were used as the basis for modeling the 303(d)-listed lower Blackwater River. The existing models were also used to develop fecal coliform TMDLs (see Fecal Coliform TMDL Development for Seven Segments in the Blackwater River Watershed, Florida, November 1999). The existing models were extended to include remaining areas draining into the listed segment. The remaining areas of the lower Blackwater River watershed were divided into 38 subwatersheds based on Florida's subwatershed coverage to spatially evaluate pollutant sources and loading and to more accurately represent the stream systems.

After the subwatersheds were delineated, reach networks within the model were established. For subwatersheds based on RF1 reach segments, reach characteristics (e.g., width, depth, length, slope, elevations) were accessed from the RF1 database. Reach characteristics for RF3 reaches were estimated based on reach network, elevation and topography coverages. Stream cross-section dimensions, including width and depth, were developed using regional curves that relate watershed size to stream cross section (Rosgen, 1996). The functions used to estimate the stream depth and width of the RF3 reaches are:

$$d = 1.4995 * A^{0.2838}$$

where d is the stream depth in feet and A is the upstream watershed area in square miles, and

$$w = 14.49 * A^{0.40}$$

where w is the stream width in feet and A is the upstream watershed area in square miles. Some reach characteristics were adjusted to result in appropriate flow output and model response.

5.3.3 Hydrologic Calibration and Meteorological Representation

The modeling time period was selected as 1975 -1995, in order to represent a range of hydrologic and climatic conditions. After developing the model to represent source contributions and in-stream response, the model was calibrated. The first step was to calibrate hydrology. Hydrology calibration involved comparison of modeled flow to observed flow at USGS gage 02370000 for 1979. This gage was assumed to be representative of hydrologic condition throughout the Blackwater watershed (see Figure 5-1). The year 1979 was selected because it represented a full range of hydrologic conditions.

The overall water balance, flow during storm events, and seasonal flow balance were examined. Various hydrologic parameters representing infiltration, interflow, groundwater, storage, and evapotranspiration were adjusted to calibrate modeled flows to existing flows. The simulated flows are plotted with the observed flows in Figure 5-2. In addition to visual comparison, statistical comparisons were made between daily model output and existing flow data. Results of the data comparison are presented in Table 5-1. As indicated in Table 5-1, the differences between simulated flows and existing flows are generally within the recommended ranges.

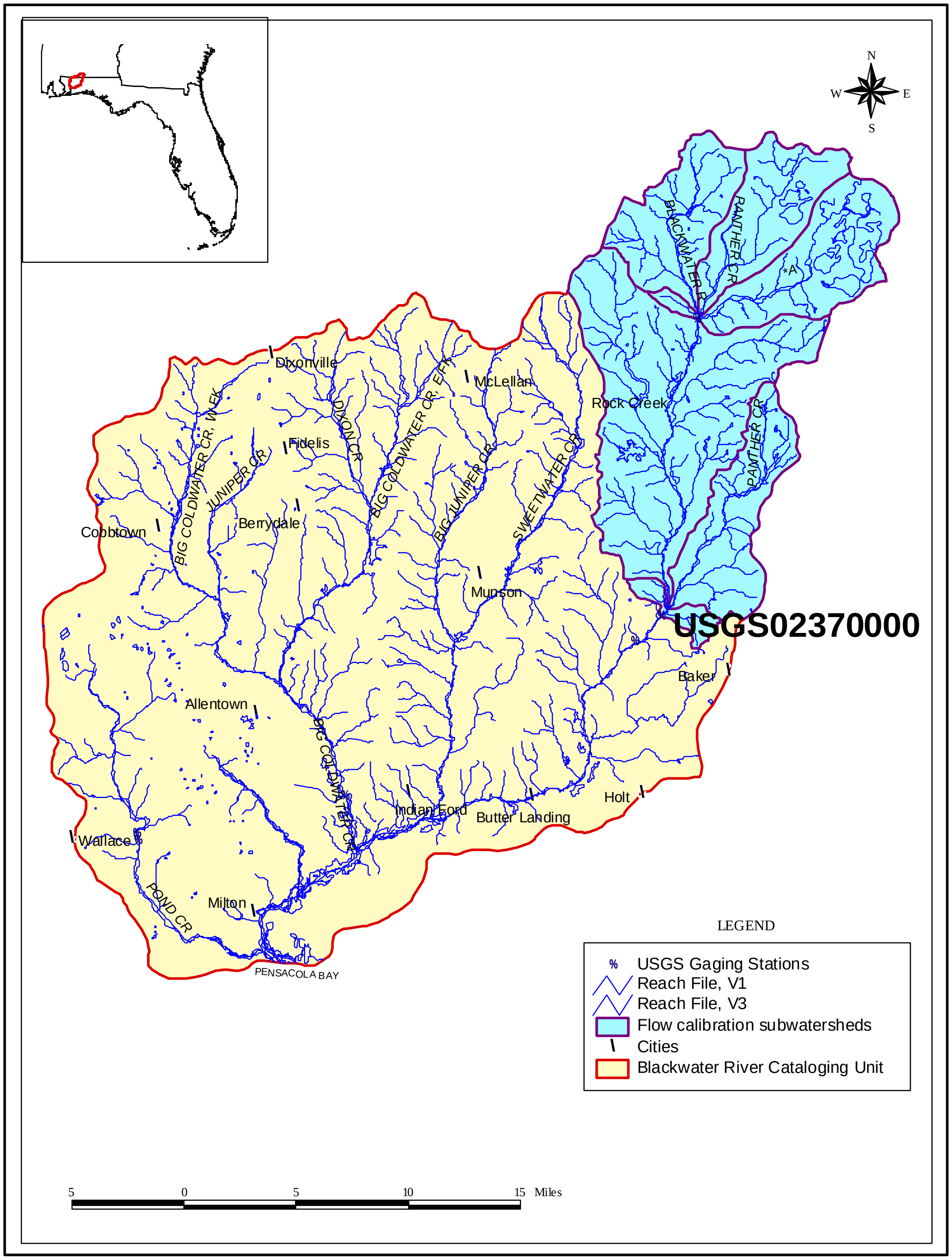

Figure 5-1. Location of USGS gage station 02370000 and the watershed used for hydrologic calibration in the Blackwater River watershed

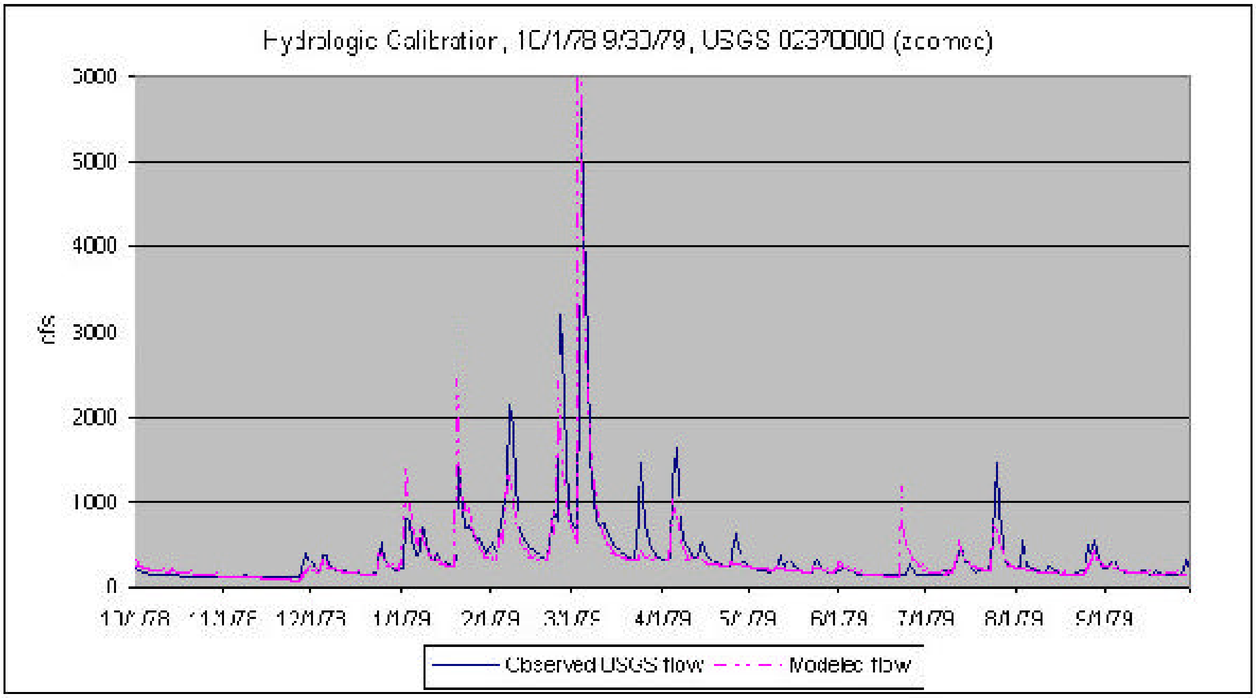

Figure 5-2. Observed and modeled flows at USGS gage 02370000, Blackwater River, Florida (10/1/79-9/30/79)

Table 5-1. Results of data comparison of simulated and observed flows (in cfs) within the calibration watershed

Calculation	Simulated	Observed	Error	Recommended Error [a]
Total flow volume	62.84	61.69	1.83 %	10 %
Total of lowest 50% of flows	12.71	12.17	4.24 %	10 %
Total of highest 10% of flows	28.61	24.91	12.93 %	15 %
Summer flow volume	10.75	11.39	-5.93 %	30 %
Fall flow volume	8.66	9.81	-13.34 %	30 %
Winter flow volume	6.50	6.63	-2.10 %	30 %
Spring flow volume	36.94	33.86	8.34 %	30 %

To represent the weather throughout the watershed, Blackman weather station in FL was used in the model. The hourly precipitation data for this station contained various intervals of accumulated, missing, or deleted data. Accumulated data represent cumulative precipitation over several hours, but the exact hourly distribution of the data is unknown. Accumulated, missing, and deleted data records were repaired based on hourly rainfall patterns at nearby stations with unimpaired data. These intervals were patched using the *normal-ratio method*, which estimates a missing rainfall record with a weighted average from surrounding stations with similar rainfall patterns according to the relationship

$$P_A = \frac{1}{n} \left(\sum_{i=1}^{n} \frac{N_A}{N_i} P_i \right)$$

where P_A is the impaired precipitation value at station A, n is the number of surrounding stations with unimpaired data at the same specific point in time, N_A is the long-term average precipitation at station A, N_i is the long-term average precipitation at nearby station i, and P_i is the observed precipitation at nearby station i. For each impaired data record at station A, n consists of only the surrounding stations with unimpaired data; therefore, for each record, n varies from 1 to the maximum number of surrounding stations. When no precipitation is available at the surrounding stations, zero precipitation is assumed at station A. The US Weather Bureau has a long-established practice of using the long-term average rainfall as the precipitation normal. This method is adaptable to regions where there is large orographic variation in precipitation.

5.3.4 Source Representation

Nonpoint Sources

The nonpoint sources within the Blackwater watersheds are represented differently in the model depending on their type and behavior. The following nonpoint sources have been identified within the listed watershed:

- General land-based runoff
- Grazing livestock
- Wildlife
- Failing septic systems
- Cattle in the stream reaches

Typically, nonpoint sources are characterized by buildup and washoff processes: they contribute bacteria to the land surface, where they accumulate and are available for runoff during storm events. These nonpoint sources can be represented in the model as land-based runoff from the land use categories to account for their contribution to coliform loading within the watersheds. Coliform accumulation rates (number per acre per day) can be calculated for each land use based on all sources contributing coliform to the surface of the land use. For this study, where specific sources were identified as contributing to a land use, accumulation rates were calculated. For example, grazing livestock and wildlife are specific sources contributing to land uses within the watershed. The land uses that experience bacteria accumulation due to livestock and wildlife include

- Cropland (wildlife)
- Forest/Vegetated (wildlife)
- Open Land (wildlife)
- Pasture (livestock and wildlife)
- Wetlands (wildlife)

Accumulation rates were specifically calculated for these land uses based on the distribution of animals by land use for each subwatershed (see Section 4. Source Assessment) and using typical fecal coliform production rates for different animal types (Table 5-2). For example, the coliform accumulation rate for pasturelands is the sum of the individual coliform accumulation rates due to contributions from grazing livestock (including milk and beef cattle, sheep, and horses) and wildlife.

Table 5-2. Fecal coliform production rates for various animals

Animal	Fecal Coliform Production Rate	Reference
Milk cow	7.1×10^{10} counts/day	ASAE, 1998
Beef cow	6.98×10^{10} counts/day	ASAE, 1998
Sheep	1.8×10^{10} counts/day	Metcalf & Eddy, 1991
Hog	8.9×10^{9} counts/day	Metcalf & Eddy, 1991
Deer	5×10^{8} counts/day	Linear interpolation; Metcalf & Eddy, 1991

Literature values for typical fecal coliform accumulation rates were used for the remaining land uses—Urban, Residential, and Other. The literature value used for residential land uses is 1.43 E+07 #/ac/day, the average of the default values for low- and high-density residential areas (Horner, 1992). The literature value used for urban land uses is the median default value of 6.19 E+06 #/ac/day for commercial land (Horner, 1992). It is assumed that the “other” land use is half the load from low-density residential, therefore, the value used to represent fecal coliform accumulation rates on other land is 5.14 E+06 #/ac/day.

Failing septic systems represent a nonpoint source that can contribute fecal coliform to receiving waterbodies through surface or subsurface malfunctions. The estimation of number of failing septic systems is discussed in Section 4.2.2. To provide for a margin of safety accounting for the uncertainty of the number, location, and behavior (e.g., surface vs. subsurface breakouts; proximity to stream) of the failing systems, failing septic systems are represented in the model as direct sources of fecal coliform to the stream reaches. Fecal coliform contributions from failing septic system discharges are included in the model with a representative flow and concentration, which were quantified based on the following information:

- Number of failing septic systems in each subwatershed (as discussed in Section 4.2.2).
- Estimated population served by the septic systems (average of county averages of people per household, obtained from 1990 Bureau of the Census data).
- An average daily discharge of 70 gallons/person/day (Horsley & Witten, 1996).
- Septic effluent concentration of 10^4 cfu/100 mL (Horsley & Witten, 1996).

The septic system contribution in the model inherently contains a margin of safety based on the assumption that all the fecal coliform bacteria discharged from failing septic systems reaches the stream. In reality, it is likely that only a portion of the bacteria will reach the stream after being filtered through the soil or after die-off during transport.

Cattle depositing manure directly into stream reaches also represent a direct nonpoint source of fecal coliform. The number of cattle producing and depositing fecal coliform in watershed streams at any given time were estimated, as discussed in Section 4.2.4. The cattle were then simulated in the model as direct sources of fecal coliform loads, with a representative flow rate (cubic feet per second) and load (counts per hour). The representative load was calculated based on the number of cows in the stream and the fecal coliform production rate for cows (Table 5-2). The flow was estimated based on the number of cows in the stream, the manure production rate of cows (ASAE, 1998) and the approximate density of cow manure.

Two different decay rates were used to represent bacteria decay/die-off in the model. A constant decay rate of 1.152 (1/day) was used to represent die-off in the streams. Land surface fecal coliform die-off was not explicitly set in the model, however, it was used indirectly to estimate maximum surface storage limits. A decay rate of 0.36 (1/day) was used in estimating the maximum surface storage limits throughout the year.

Point Sources

Discharge monitoring reports (DMRs) and any other available data were used to characterize the point sources to be represented in the model within the selected watersheds. Representative effluent flow rates (ft^3/s) and loading (counts/hour) were determined and input to the model for point source characterization as shown in Table 5-3. Data for fecal coliform loading rates specific to Milton STP were not available, therefore the maximum permitted fecal coliform discharge concentration of 200 counts/100 mL was assumed for the point source.

Table 5-3. Flow and loading characteristics of point source dischargers within the listed watershed

Point Source	Flow (ft^3/s)	Fecal Coliform Loading Rate (counts/hour)
Milton STP	1.8	3.6 E+8

5.3.5 Water Quality Calibration

After the hydrologic calibration was completed and sources were most appropriately characterized and represented in the model, the modeled in-stream fecal coliform concentrations were compared to available observed data. Parameters representing such processes as bacteria accumulation and interflow and groundwater concentrations were adjusted to calibrate modeled water quality to the observed ambient water quality data. Eight water quality stations within the watershed were examined for use in calibration. Station 33030019 was chosen for calibration because it had data available during a portion of the modeling time period (1991-1995) and had some mix of baseflow and peak concentrations.

In some cases, there was some uncertainty concerning the temporal comparison of modeled concentration peaks and observed peaks. The observed water quality represents an ambient concentration from a grab sample and the modeled water quality represents daily average concentrations. If there is a storm event during the sampling day, the grab sample may reflect a concentration on the rising or falling curve of the pollutograph or the peak storm concentration. To confirm calibration of the model's water quality and to avoid overestimation of the concentration peaks, daily output from the model was compared to the observed ambient data. Figure 5-3 presents calibrated daily modeled fecal coliform concentrations and observed fecal coliform concentrations at station 33030019 for January 1, 1992 through December 31, 1995.

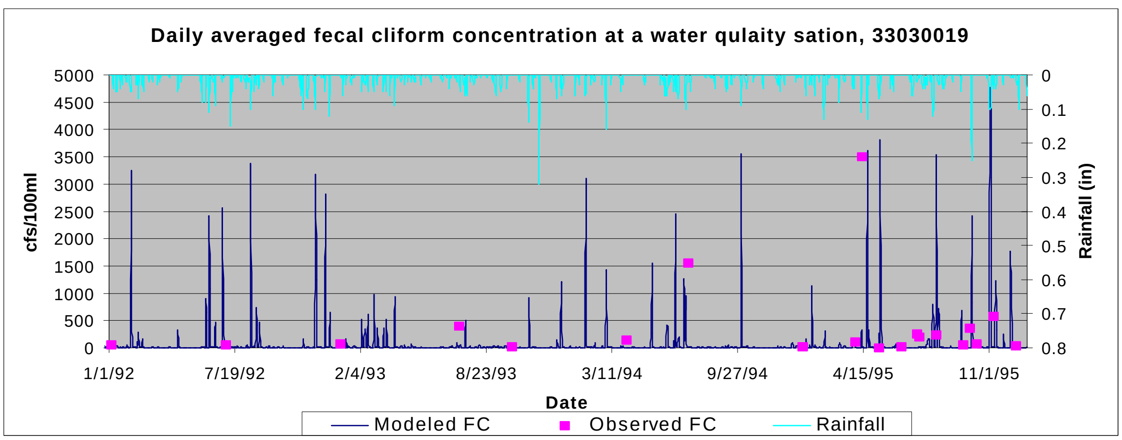

Figure 5-3. Daily averaged modeled and observed fecal coliform concentrations at water quality monitoring station 33030019

6. TMDL

This section presents the TMDL developed for fecal coliform for the Blackwater River watershed—Blackwater River (downstream segment). Model output for 1994 was used to determine the TMDL and allocations because modeled water quality during 1994 represented recent critical conditions during the modeling period. Allocations were determined on a 30-day basis for 1994 and represented compliance with the 200 counts/100 mL as a geometric mean standard (actually 190 counts/100 mL when considering the margin of safety).

The overall 30-day TMDL allocations for the Blackwater River (downstream segment) are presented in the following table.

Source	**Existing Fecal Coliform Load (counts/30 days)**	**Allocated Fecal Coliform Load (counts/30 days)**
Nonpoint Sources		
Cropland	3.10 E+15	3.10 E+15
Forest/Vegetated	6.48 E+15	6.48 E+15
Open Land	3.42 E+11	3.42 E+11
Other	3.78 E+11	3.78 E+11
Pasture	4.99 E+17	4.99 E+17
Residential	6.66 E+13	6.66 E+13
Urban	2.00 E+13	2.00 E+13
Wetlands	1.19 E+12	1.19 E+12
Failing Septic Systems	2.71 E+09	2.71 E+09
Cattle in the Stream	8.92 E+10	8.92 E+10
Point Sources		
Milton STP	2.63 E+11	2.63 E+11

Total Existing Load	**5.08 E+17**	**Total Load Allocation**	**5.08 E+17**
		Wasteload Allocation	**2.63 E+11**
		Margin of Safety[1]	**2.67 E+16**
		Reserve for Future Growth/Activities	**1.78 E+13**
		TMDL = Loading Capacity =	**5.35 E+17**

[1] The MOS was included implicitly in the analysis with conservative assumptions and explicitly with a target/endpoint of 190 counts/100 mL as a monthly geometric mean. See Section 6.1.
[2] A Reserve for Future Growth/Activities was calculated for watersheds with existing loads that did not exceed the target/endpoint of 190 counts/100 mL. See Section 6.2

6.1 MARGIN OF SAFETY

The margin of safety (MOS) is a required part of the TMDL development process. There are two basic methods for incorporating the MOS (USEPA, 1991):

- Implicitly incorporate the MOS using conservative assumptions to develop allocations or
- Explicitly specify a portion of the total TMDL as the MOS using the remainder for wasteload and load allocations.

The MOS was incorporated both implicitly and explicitly in developing the TMDLs. Assumptions made in simulating failing septic system loads is an example of implicit conservative assumptions used in the modeling process.

The simulation of load contribution from failing septic systems assumes that all fecal coliform bacteria discharged by the failing systems reaches the stream. In reality, it is likely that only a portion of the bacteria will reach the stream after filtration through soil or surface die-off. Additionally, these discharges from failing systems are assumed to be constant throughout the year, while failures may actually occur less frequently.

To provide an explicit margin of safety, the water quality target for the TMDL was established at a geometric mean of 190 counts/100 mL for a 30-day period, which is 5 percent lower than the water quality standard of 200 counts/100 mL.

6.2 RESERVE FOR FUTURE GROWTH/ACTIVITIES

If the watershed's existing load to the watershed was found to be below the target/endpoint, which was the geometric mean water quality standard less the explicit margin of safety (190 counts/100 mL), then a "reserve for future growth/activities" was calculated. The reserve for future growth/activities is the amount of fecal coliform loading that can be contributed to the watershed on top of the existing loading without exceeding the target concentration of 190 counts/100 mL. The reserve for future growth was calculated by increasing the fecal coliform contributions from the most significant source in the watershed until the concentrations reached the target/endpoint.

6.3 SEASONALITY

Seasonality was considered during the TMDL analysis through representation of conditions throughout an entire year. Seasonal differences in coliform levels could be caused by seasonal variations in precipitation and climate or by seasonal differences in activities in the watershed (e.g., land application of agricultural waste, recreational activities, etc.). Seasonality was evaluated using observed water quality and flow data. Water quality samples were collected quarterly at several monitoring stations in the watershed, providing coliform samples during different times of the year. These data do not suggest a distinct seasonal pattern of in-stream coliform levels, primarily because they do not provide consistent records of coliform levels during and across seasons and they do not have corresponding flow values. There is an apparent difference in flow volumes over seasons, indicating varying hydrologic as well as water quality conditions across seasons; although the seasonal differences do not consistently appear over the period of record for flow in the watershed. Although the modeling represented seasonal variation, the TMDLs were developed on a 30-day basis.

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Appendix A

Land Use Classification

Table A-1. Land use classifications in original land use coverages and their associated TMDL classification

Land Use Code	Description	TMDL Classification
	Florida classifications	
8110	Airports	Urban
2540	Aquaculture	Water
6110	Bay Swamps	Wetlands
7450	Burned Areas	Other
1480	Cemeteries	Open Land
1400	Commercial and Services	Urban
1860	Community Recreational Facilities	Urban
4410	Coniferous Plantations	Forest/Vegetated
1760	Correctional	Urban
2100	Cropland and Pastureland	Cropland/Pasture
6210	Cypress	Wetlands
7400	Disturbed Land	Other
1710	Educational facilities	Urban
8310	Electrical Power Facilities	Urban
8320	Electrical Power Transmission Lines	Urban
6440	Emergent Aquatic Vegetation	Wetlands
1600	Extractive	Other
2300	Feeding Operations	Pasture
4430	Forest Regeneration Areas	Forest/Vegetated
6410	Freshwater Marshes	Wetlands
1820	Golf Courses	Open Land
1660	Holding ponds	Other
1500	Industrial	Urban
6160	Inland Ponds and Sloughs	Water
6530	Intermittent Ponds	Water
1420	Junk Yards	Urban
5200	Lakes	Water

Land Use Code	Description	TMDL Classification
1740	Medical and Health Care	Urban
1730	Military	Urban
4340	Mixed Coniferous/Hardwood	Forest/Vegetated
1120	Mobile Home Units	Residential
1320	Mobile Home Units, High-Density	Residential
1220	Mobile Home Units, Medium-Density	Residential
2400	Nurseries and Vineyards	Forest/Vegetated
1640	Oil and Gas Fields	Urban
8170	Oil, Water, or Gas Transmission Lines	Other
1900	Open Land (Urban)	Open Land
2600	Other Open Lands (Rural)	Open Land
10	Outside Study Area	Other
1850	Parks and Zoos	Open Land
1800	Recreational	Urban
1720	Religious	Urban
5300	Reservoirs	Water
1300	Residential, High-Density	Residential
1100	Residential, Low-Density	Residential
1200	Residential, Medium-Density	Residential
7500	Riverine Sandbars	Other
8140	Roads and Highways	Urban
1620	Sand and Gravel Pits	Other
7200	Sand other than Beaches	Other
3200	Shrub and Brushland	Forest/Vegetated
5100	Streams and Waterways	Water
1610	Strip Mines	Other
1450	Tourist Services	Urban
8210	Transmissions Towers	Urban
8100	Transportation	Urban
2200	Tree Crops	Forest/Vegetated
4100	Upland Coniferous Forests	Forest/Vegetated

Land Use Code	Description	TMDL Classification
4200	Upland Hardwood Forests	Forest/Vegetated
6400	Vegetated Non-Forested Wetlands	Wetlands
6200	Wetland Coniferous Forests	Wetlands
6300	Wetland Forested Mixed	Wetlands
6100	Wetland Hardwood Forest	Wetlands
6900	Wetland Scrub Shrub	Wetlands

Appendix B
Water Quality Data

The following table presents the data used to evaluate the water quality conditions in the Blackwater River watershed (downstream segment).

STATION	LOCATION	DATE	FECAL COLIFORM COUNTS PER 100 MILLILITERS
33030020	Clear Creek SR 191 BRI NE Milton	8/26/80	230
		9/16/80	43
		10/8/87	70
		7/11/93	800
		10/3/93	10
		1/9/94	20
		4/3/94	50
		7/10/94	80
		1/8/95	10
		4/2/95	30
		7/9/95	30
		10/1/95	20
		1/7/96	50
		4/7/96	20
		7/7/96	100
		10/6/96	140
		1/5/97	190
		4/6/97	200
		7/21/97	20
		10/20/97	10
		1/26/98	60
33030028	Blackwater River below Grain Ele	7/1/90	50
		1/6/91	140
		7/7/91	140
		1/5/92	10
		7/5/92	70
		1/3/93	280
		7/11/93	120
		10/3/93	20
		4/3/94	10
		7/10/94	160
		1/8/95	350
		4/2/95	110
		7/9/95	220
		10/1/95	100
		1/7/96	380
		4/7/96	10
		7/7/96	1000
		10/6/96	3420
		1/5/97	180
		4/6/97	620
		7/21/97	280
		10/20/97	10
		1/26/98	100
33030019	Pond Creek Hwy 90 Br W Milton	9/17/80	4300
		5/6/87	110

		7/1/90	70
		1/6/91	70
		7/7/91	140
		1/5/92	60
		7/5/92	60
		1/3/93	80
		7/11/93	390
		10/3/93	10
		4/3/94	150
		7/10/94	1560
		1/8/95	20
		4/2/95	110
		4/12/95	3500
		5/10/95	1
		6/14/95	20
		7/9/95	250
		7/12/95	200
		8/9/95	240
		9/20/95	60
		10/1/95	360
		10/11/95	80
		11/8/95	580
		12/13/95	40
		1/7/96	460
		1/10/96	10
		2/14/96	60
		3/13/96	20
		4/7/96	70
		7/7/96	2460
		10/6/96	560
		1/5/97	120
		2/24/97	180
		3/3/97	70
		3/10/97	52
		3/18/97	60
		3/25/97	140
		3/31/97	96
		4/6/97	1800
		4/8/97	120
		4/15/97	32
		4/22/97	260
		4/29/97	80
		5/6/97	168
		5/13/97	140
		5/20/97	1100
		5/27/97	300
		7/1/97	700
		7/8/97	240
		7/15/97	120
		7/21/97	220
		7/22/97	180
		7/29/97	100
		8/5/97	100
		8/12/97	180

		8/19/97	330
		8/26/97	190
		9/2/97	400
		9/9/97	240
		9/16/97	90
		9/23/97	280
		9/30/97	150
		10/7/97	160
		10/14/97	70
		10/20/97	60
		10/21/97	50
		10/28/97	310
		11/4/97	150
		11/12/97	1100
		11/18/97	80
		11/25/97	120
		1/26/98	40
33030011	Blackwater River N Hwy 90 Br	8/26/80	230
		11/3/81	100
		6/6/90	100
		7/1/90	50
		1/6/91	70
		7/7/91	130
		1/5/92	20
		7/5/92	20
		1/3/93	130
		7/11/93	70
		10/3/93	260
		1/9/94	20
		4/3/94	50
		7/10/94	200
		1/2/95	160
		1/8/95	380
		7/9/95	800
		10/1/95	160
		1/7/96	180
		4/7/96	20
		7/7/96	620
		10/6/96	300
		4/6/97	260
		7/21/97	2200
		10/20/97	20
		1/26/98	60
33030013	Blackwater River S Milton STP Outfall	8/26/80	24000
		9/16/80	43
		3/3/81	50
		11/16/82	60
		6/6/90	240
33030017	Blackwater River MO Big Coldwater Cr	8/14/80	230
		8/26/80	23
		9/16/80	4
		2/24/97	260

		3/3/97	50
		3/10/97	16
		3/18/97	20
		3/25/97	20
		3/31/97	44
		4/8/97	90
		4/15/97	32
		4/22/97	1060
		4/29/97	340
		5/6/97	8
		5/13/97	10
		5/20/97	190
		5/27/97	160
33030026	Blackwater River N of Harold	7/1/97	400
		7/8/97	120
		7/15/97	20
		7/22/97	100
		7/29/97	10
		8/5/97	50
		8/12/97	170
		8/19/97	30
		8/26/97	32
		9/2/97	30
		9/9/97	20
		9/16/97	40
		9/23/97	460
		9/30/97	20
		10/7/97	40
		10/14/97	30
		10/21/97	10
		10/28/97	720
		11/4/97	150
		11/12/97	230
		11/18/97	30
		11/25/97	50
33030042	Panther Creek JHN Riley Barnhill Rd Oka. Co. Sect. 11	8/18/92	60
		2/16/93	170
		6/22/93	20
		3/14/94	30
		8/11/94	200
		1/26/95	10
		2/22/96	70

Appendix C
Cattle and Septic Loading Rates used in TMDL Development for the Blackwater River Watershed

Table C-1. Failing septic system fecal coliform loading rates used in TMDL development for the Blackwater River watershed

Subwatershed	Fecal Coliform Rate (counts/hr)	Septic Flow (cfs)
1	3715286.96	0.00037
2	12080276.24	0.00119
3	13937487.87	0.00137
4	9954147.23	0.00098
5	11772362.42	0.00116
6	7902637.82	0.00078
7	14147983.92	0.00139
8	2124260.36	0.00021
9	916506.00	0.00009
10	10098383.54	0.00099
11	6584638.27	0.00065
12	415519.74	0.00004
13	3498309.84	0.00034
14	8375841.52	0.00082
15	19834554.84	0.00195
16	5308127.82	0.00052
17	12489828.50	0.00123
18	546064.25	0.00005
19	342852.54	0.00003
20	2007477.49	0.00020
21	1375647.14	0.00014
22	22218422.14	0.00218
23	4114458.64	0.00040
24	10070175.09	0.00099
25	6656080.49	0.00065
26	693216.81	0.00007
27	2365824.74	0.00023
28	3910774.34	0.00038
29	2405915.85	0.00024
30	1520828.62	0.00015
31	6746449.55	0.00066
32	3822954.95	0.00038
33	2033127.47	0.00020
34	2410609.11	0.00024
35	10567981.20	0.00104
36	1605060.33	0.00016
37	2556992.57	0.00025
38	658361.85	0.00006

Table C-2. In-stream cattle fecal coliform loading rates used in TMDL development for the Blackwater River watershed

Subwatershed	Load of Fecal Coliform (counts/hr)	Flow (cfs)
1	121737958.83	3.57E-07
2	265821631.50	7.79E-07
3	153548918.83	4.50E-07
4	709521158.02	2.08E-06
5	330030654.34	9.68E-07
6	173803972.91	5.10E-07
7	327052180.49	9.59E-07
8	559763838.15	1.64E-06
9	7933050.61	2.33E-08
10	166722937.80	4.89E-07
11	4119707845.25	1.21E-05
12	0.00	0.00E+00
13	327131377.46	9.59E-07
14	2290989116.99	6.72E-06
15	2037984934.08	5.98E-06
16	185588992.07	5.44E-07
17	1325177431.01	3.89E-06
18	9007019.52	2.64E-08
19	41526798.88	1.22E-07
20	64072986.79	1.88E-07
21	0.00	0.00E+00
22	3356346242.23	9.84E-06
23	77232686.11	2.26E-07
24	1308769572.30	3.84E-06
25	2092280440.68	6.13E-06
26	26416062.12	7.75E-08
27	778514498.42	2.28E-06
28	225547796.41	6.61E-07
29	167875664.40	4.92E-07
30	24572409.22	7.20E-08
31	539748148.52	1.58E-06
32	404642856.20	1.19E-06
33	115308464.86	3.38E-07
34	80647907.37	2.36E-07
35	6421070881.43	1.88E-05
36	552298894.32	1.62E-06
37	2644493777.31	7.75E-06
38	1732551.61	5.08E-09